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The influence of the mixing technique on the content of voids in two polyether impression materials

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Summary

One of the most critical problems related to hand mixing of an elastomeric impression material is air entrapment during spatulation. This leads to the formation of both surface and subsurface bubbles which in turn may result in inaccurate dental impressions and/or jeopardize their physical properties.

In the present study the influence of the mixing technique has been determined by evaluating the surface area and the number of voids in two polyether materials (Permadyne and Impregum, Espe, Seefeld, Germany). The techniques tested were the stropping technique as hand-mixing and the Pentamix® device (Espe) as mechanical mixing.

Eighty special trays (10 mm3 20 mm3 43 mm) featuring 10 transverse slots were fabricated and divided into four groups of twenty units. Groups 1 and 2 received the hand-mixed materials Permadyne high viscosity and Impregum F, respectively. Groups 3 and 4 (Pentamix® group) received the mechanically mixed materials Permadyne Penta H and Impregum Penta, respectively. After polymerization, 10 slices of material were obtained for each tray by sectioning through the tray slots with a surgical blade. The slices were glued on a card and black and white photographs were taken. Subsequently, the negative films were placed on a viewing box and digitized with a video camera. A special software program allowed to identify and calculate the total surface area and the number of voids.

Significant differences between the "stropping" groups (groups 1 and 2) and "Pentamix" groups (groups 3 and 4) were found. The mechanical mixing (Pentamix) generated the smallest number and total surface area of voids, while no significant differences were detected between Permadyne Penta H and Impregum Penta.

Clearly, mechanical mixing represents a marked improvement over the traditional hand-mixing methods.

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Introduction

Four major classes of elastomeric impression materials are in use in dental medicine when it comes to precision impressions: polysulfides, condensation-reaction polysiloxanes, addition-reaction vinylpolysiloxanes and polyethers (CRAIG 1997).

Different viscosities – light-bodied, regular-bodied, heavy-bodied, and putty – are available, to be used according to a specific clinical objective. These products are designed for either spatula-mixing (two paste systems, base and catalyst), auto-mixing (automix systems) or hand-kneading (putty materials).

Several potential shortcomings may arise by using the spatulated systems:

- Incorrect ratios (by weight or volume) for a two paste system can affect both the setting time as well as the resulting mechanical properties (KECK & DOUGLAS 1984, PHILLIPS 1991);
- The possible presence of contaminants in the atmosphere, on the spatula or on the mixing pad may alter the physical characteristics of the completed impression (KECK 1985);
- Inhomogeneous mixing can lead to incomplete polymerization which may cause – among other deficiencies – a loss of detail (PHILLIPS 1991, CRAIG 1997);
- During the actual spatulation process it is difficult to avoid entrapment of air which may result in surface and subsurface void or bubble formation (STACKHOUSE 1983, KECK 1985). This leads to inaccurate casts and may require taking a new im-

pression when critical areas of tooth preparations are involved.

To overcome some of these potential shortcomings, automixing systems have been proposed and their performance analysed (CHONG et al. 1991, LIM et al. 1992, WIRZ et al. 1998a, WIRZ et al. 1998b). More recently, a mechanical mixing device (Pentamix® Espe, Espe Dental Medizin, D-82229 Seefeld, Germany) has been advocated as advantageous for mixing elastomeric compounds because it "avoids air inclusion" within the body of the impression material.

Consequently, the objective of this in vitro study was to determine the influence of the mixing technique (spatula versus mechanical) on the resulting amount of air entrapment in two polyether materials.

Materials and methods

The polyether materials tested were Impregum® (Espe) and Permadyne® (Espe). According to the technique described by STACKHOUSE (1983) eighty special metal trays, 10 mm3 20 mm 3 43 mm, featuring ten transverse slots for subsequent sectioning of the impressions, were fabricated to receive the mixed impression materials. The following two mixing techniques were investigated:

Stropping technique

Utilizing a flexible spatula, base (20 gr) and catalyst (10 gr) of Permadyne® high viscosity (Group 1) or Impregum® F (Group 2), were mixed according to the stropping technique by one operator, until a uniform color was obtained, respecting the manufacturer's instructions related to mixing time (Permadyne: 30 sec.; Impregum F: 45 sec.).

Once the mixing was completed, the material was removed from the pad with a single motion and placed in the slotted impression tray by a single scraping movement.

Pentamix® device

Permadyne® Penta H (high viscosity) (Group 3) and Impregum® Penta (Group 4) were used with the Pentamix® device, strictly according to the manufacturer's instructions, and placed directly in the tray.

For each of the four groups, 20 impression trays were filled, subsequently inverted, pressed against a glass slab and left for a 20-minutes polymerization period at room temperature. All manipulations were carried out by the same operator.

Once the polymerization was completed, ten slices of impression material were obtained from each tray by sectioning through the slots of the tray with a surgical blade. Subsequently, the slices were glued on a card in sequence and black and white photographs taken in a standardized fashion.

As an alternative to the method described by CHONG & SOH (1990), the negative films were then placed on a viewing box and digitized with a 12 bit video camera (Kodak Eikonix Corp., Bedford, Mass.) at a frame store resolution of 13643 1580 pixels, as described in detail by DUBREZ et al. (1995). The data were stored on a hard disk, visualized on a Sun SPARC (Sun Microsystem Inc., Mountain View, Calif.) work station and analyzed with LaboImage software (Computer Science Center, Geneva University) (JACOT-DESCOMBES et al. 1991). This software program allowed to identify voids having a minimal diameter of 0.03 mm in a given specimen, based on a comparison between different grey levels. Accordingly, the total surface area (in mm^2) and the number of voids were calculated.

For the values of surface area and the number of voids a one-way analysis of variance (ANOVA) was performed and a Bonferroni test used to identify differences among the groups.

Results

The influence of the mixing procedure on the amount of entrapped air becomes apparent on a simple visual observation of the sectioned specimens (Figs 1–4). Indeed, the amount of porosities appears drastically reduced when a mechanical mixing device (PENTAMIX®) is used (Figs 2 and 4).

Mean values and standard deviations related to the void surface area of the four groups are given in Table I. For the hand-mixed specimens, the mean amount of air entrapped totalized a surface area of 11.35 mm^2 with a standard deviation of 6 2.70 (group 1 – Permadyne HV) and 14.52 mm^2 6 2.29 (group 2 – Impregum F), respectively. Concerning mechanical mixing,

Fig. 1 Ten sliced specimens of an impression sample of group 1 (Permadyne HV, "stropping technique"). A considerable amount of voids is visible.

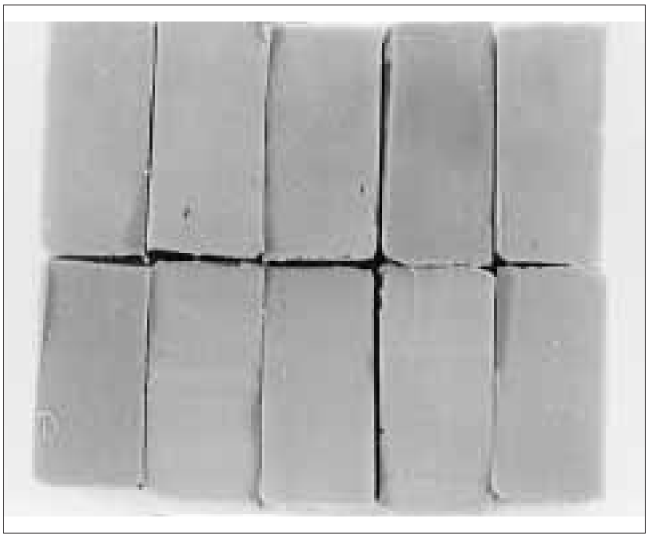

Fig. 2 Ten sliced specimens of an impression sample of group 3 (Permadyne Penta H "mechanical mixing"), containing a minimal amount of voids.

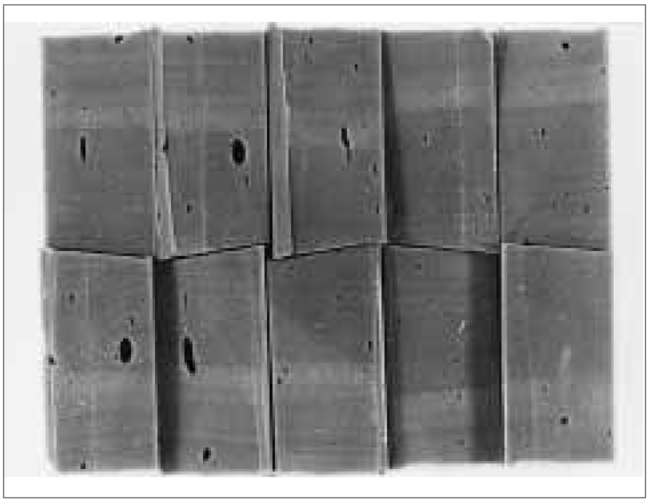

Fig. 3 Ten sliced specimens of an impression sample of group 2 (Impregum F, "stropping technique"). Numerous bubbles can be noticed.

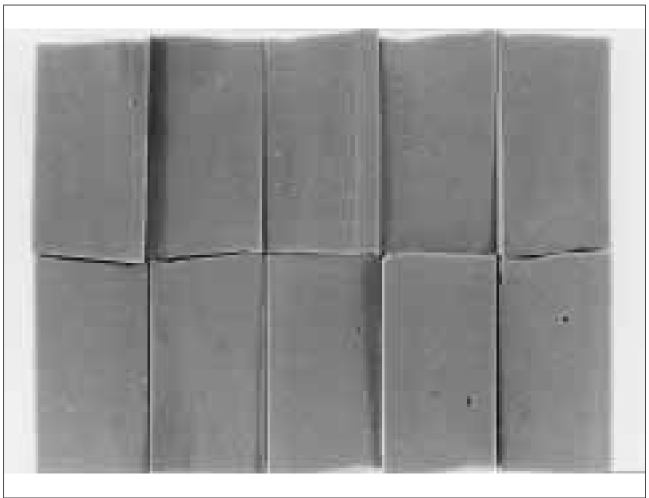

Fig. 4 Ten sliced specimens of an impression sample of group 4 (Impregum Penta, "mechanical mixing"), containing a minimal number of voids.

the corresponding mean amount of void surfaces revealed 0.01 mm^2 6 0.02 (group 3 – Permadyne Penta H) and 0.29 mm^2 6 1.24 (group 4 – Impregum Penta), respectively. As for the number of porosities (bubbles) present in the various specimens, the following data were found (Tab. I): 42.10 6 28.22 (group 1 – Permadyne HV), 85.40 6 32.05 (group 2 – Impregum F), 0.15 6 0.67 (group 3 – Permadyne Penta H), and 0.55 6 1.64 (group 4 – Impregum Penta).
The analysis of variance of void surface areas showed significant differences among the four groups, and, in order to identify specific differences, Bonferroni's test was applied (Tab. II).
Significant differences between "stropping" (groups 1 and 2) and "Pentamix" groups (groups 3 and 4) were found. Additionally, statistically significant differences between group 1 and group 2 were detected, group 1 showing significantly fewer void areas as compared to group 2. However, the comparison between group 3 (PERMADYNE PENTA H) and group 4 (IMPREGUM PENTA) failed to reveal any statistically significant differences at the 0.05 level of probability. Concerning the actual number of bubbles,

Tab. I Mean values and standard deviations of void surface areas and number of porosities in the four groups.

Group (Material)	Void surface area MEAN (mm^2)*	SD	Number of porosities (bubbles) MEAN	SD
Group 1 (Permadyne HV)	11.35	2.70	42.1	28.2
Group 2 (Impregum F)	14.52	2.29	85.4	32.1
Group 3 (Permadyne Penta H)	0.01	0.02	0.15	0.67
Group 4 (Impregum Penta)	0.29	1.24	0.55	1.64

* Specimen surface = 2000 mm^2

Tab. II Comparison between groups as a function of void surface areas (Bonferroni's test).

	Group 2 (Impregum F)	Group 1 (Permadyne HV)	Group 3 (Permadyne Penta H)
Group 1 (Permadyne HV)	–3,1695*		
Group 3 (Permadyne Penta H)	–14,5123*	–11,3428*	
Group 4 (Impregum Penta)	–14,2348*	–11,0653*	0.2775

*: $p<0.001$

the Bonferroni specific test showed the same differences as those found when analysing void surface areas.

Discussion

The principal factors contributing to the formation of voids in elastomeric impression materials have been classified by (Soh & Chong 1991) as "operator-related" and "non-operator-related". Among the operator-related factors, one should mention the mixing technique at the chairside, the loading of the material into the tray or syringe, as well as its injection around the teeth. In the present study, only the impact of the mixing procedure on the resulting air entrapment has been addressed, confirming that the "stropping" technique leads to a considerable amount of voids, as previously reported (Reisbick et al. 1982, Stackhouse 1983, Keck 1985, Stackhouse et al. 1987, Chong et al. 1989, Soh & Chong 1991).
Most dental personnel are well aware of the difficulties associated with hand-mixing of elastomeric impression materials, and great care is generally taken in trying to overcome such problems. However, when using traditional manual techniques like "stropping" or "stirring", it is practically impossible to avoid inclusion of air in the bulk of the manipulated compound (Scrabeck et al. 1986). In contrast, the use of a mechanical mixing device allows to eliminate the relative "messiness" of hand spatulation as well as the variability among different operators. A uniform ratio of base and catalyst is consistently dispensed, resulting in a homogeneous mixing and, ultimately, in optimal physical properties of the impression material once its polymerization completed (Craig 1997). This corroborates data pub-

lished by WIRZ et al. (1998a+b) who reported a marked reduction of voids when mechanical instead of manual mixing was used, which in turn led to a significantly lower thermal contraction at the moment of impression removal from the oral cavity. Clearly, mechanical mixing using the Pentamix® device is an improvement over the traditional mixing methods of polyether elastomeric impression compounds. Furthermore, the risk for contaminations is minimized due to the fact that the material is neither in contact with mixing pads, nor with the atmosphere prior to the mixing.

Conclusions

Within the conditions of this study, the following conclusions can be drawn:

1. None of the tested mixing techniques allowed to obtain a totally "bubble-free" mix.
2. The hand-mixing (stropping) of polyether materials produced the highest number and total surface area of porosities.
3. Impregum F (Group 2) presented significantly more bubbles when compared to Permadyne high viscosity (Group 1).
4. The mechanical mixing (Pentamix) showed the smallest number and the lowest total surface area of porosities, with no significant difference between Permadyne Penta H (Group 3) and Impregum Penta (Group 4).

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Zusammenfassung

Lufteinschlüsse während des Mischvorganges stellen eines der Hauptprobleme bei der herkömmlichen, manuellen Verarbeitung von elastomeren Abformstoffen dar. Dies führt sowohl zu oberflächlichen als auch zu tiefer liegenden Blasenbildungen, welche einerseits ungenaue Abformungen und/oder eine generelle Beeinträchtigung der physikalischen Materialeigenschaften zur Folge haben können.
Die vorliegende Studie hatte zum Ziel, den Einfluss der Mischtechnik auf die Anzahl von Blasen und deren resultierende Gesamtoberfläche in zwei Polyäther-Abformstoffen (Permadyne und Impregum, Espe Dental, Seefeld, Deutschland) zu bestimmen. Als Mischtechniken wurden die Spateltechnik als Verteter der manuellen Methoden und der Pentamix®-Apparat (Espe Dental) als Verteter der mechanischen Methoden untersucht.
Achtzig spezielle Abformträger (10 mm3 20 mm3 43 mm) mit 10 transversal verlaufenden Einschnitten wurden hergestellt und in vier Gruppen von je zwanzig Einheiten aufgeteilt. Die Abformträger der Gruppen 1 und 2 wurden mit den handgemischten Abformstoffen Permadyne high viscosity und Impregum F beschickt, während diejenigen der Gruppen 3 und 4 (Pentamix®-Gruppen) die maschinell gemischten Materialien Permadyne Penta H und Impregum Penta erhielten. Nach abgeschlossener Polymerisation wurden von jedem Abformträger 10 Schnitte definierter Dimension gewonnen, indem das erhärtete Abformmaterial mit Rasierklinge im Bereich der vorfabrizierten Einschnitte durchtrennt wurde. Die so gewonnenen Schnitte wurden auf einer speziellen Unterlage fixiert, worauf standardisierte Schwarz/Weiss-Fotografien hergestellt wurden. Die entsprechenden Negative wurden dann mittels Negatoskop und Video-Camera digitalisiert. Ein speziell entwickeltes Software-Programm ermöglichte in der Folge, die Leerräume zu identifizieren und sowohl deren Gesamtoberfläche als auch die Anzahl der vorhandenen Blasen zu berechnen.
Es wurden statistisch signifikante Unterschiede zwischen den handgemischten Gruppen (1 und 2) und den maschinell gemischten Gruppen (3 und 4) gefunden. Mechanisches Mischen (Pentamix) verursachte bei weitem die geringste Anzahl an Blasen sowie die kleinste Gesamtoberfläche von Leerräumen, wobei keine statistisch signifikanten Unterschiede zwischen den Materialien Permadyne Penta H und Impregum Penta ermittelt wurden.
Maschinelles Mischen von Polyäther-Abformstoffen stellt somit eine deutliche Verbesserung gegenüber den herkömmlichen, manuellen Mischmethoden dar.

Résumé

L'inclusion de bulles d'air représente un des problèmes majeurs lors du malaxage manuel de matériaux d'empreintes. Ces bulles se situent aussi bien à la surface que dans les couches profondes, résultant en une empreinte imprécise et/ou en une diminution générale des propriétés physiques du matériau.
Dans l'étude présente l'influence de la technique de malaxage a été déterminée par évaluation du nombre de vides et de leur surface globale au sein de deux matériaux polyéther (Permadyne et Impregum, Espe Dental, Seefeld, Allemagne). Les techniques comparées étaient la spatulation, en tant que malaxage manuel et l'appareil Pentamix® (Espe) pour un malaxage mécanique.
Quatre-vingt porte-empreintes spéciaux (10 mm3 20 mm3 43 mm), avec 10 fentes transversales, ont été fabriqués, puis divisés en quatre groupes de vingt unités. Les groupes 1 et 2 ont été chargés avec les matériaux «Permadyne high viscosity» et Impregum F, et malaxés manuellement. Les groupes 3 et 4 (groupes Pentamix®) ont reçu les matériaux Permadyne Penta H et Impregum Penta, mélangés mécaniquement. Après polymérisation, 10 tranches de matériau ont été obtenues de chaque porte-empreinte à l'aide d'un bistouri chirurgical utilisé au niveau des fentes préfabriquées. Les coupes ont été fixées sur un support, puis photographiées en noir et blanc. Les négatifs de film ont été placés sur un négatoscope et digitalisés à l'aide d'une caméra vidéo. Un logiciel spécial a permis en suite d'identifier et de calculer le nombre de vides, ainsi que la surface totale occupée par ces vides.
Des différences statistiquement significatives ont été trouvées entre les groupes de malaxage manuel (groupes 1 et 2) et les groupes de mélange mécanique (3 et 4). Le malaxage mécanique (Pentamix®) a généré le nombre de loin le plus petit de vides et de leur surface totale. Aucune différence significative n'a été détectée entre Permadyne Penta H et Impregum Penta.
Le malaxage mécanique représente donc une amélioration significative par rapport aux méthodes traditionnelles de mélange manuel.

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